

Reconstruction of the transport of the *moai* statues and *pukao* hats

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Everyone who sees the *moai* statues on Easter Island is surprised that these giants were transported across the island by primitive aborigines. There are some problems in effecting transport: the first is their weight. Next is the fact that each statue was transported in one piece. The aborigines finished them in the area of the quarry and after that each was moved to its position on an *ahu* platform. There are many theories about this mystery of Easter Island. I tried to find a solution with the help of my experience as an engineer. Therefore some of my ideas and claims may not exactly match the archaeological point of view.

One of the suggested methods interested me very much. The old legends claim that statues simply walked. The results of my research surprised me. My calculations have told me that the islanders could be correct. I estimated that the transport of the *moai* statues by this method could be ten times easier than pulling the *moai* on a sledge, as is often shown in drawings. This test was conducted by Thor Heyerdahl on Easter Island in 1955: it took 180 people to pull a 10 ton statue.

The idea of a big *moai* tilting and twisting looks unbelievable and impossible at first glance. But from a technical point of view, this way of moving is very effective. This is a common method for moving tall objects all over the world. Could it have been used by the old builders of *moai*? The principle is based on twisting a load on the edges of its base. The real problem is finding a way of inducing the heavy statue to twist.

There are several possibilities. The basic solution is pulling alternate sides of the load forward. This makes the load 'walk'. The transport effort can be reduced by tilting the load to the sides which reduces the friction. I made calculations about this kind of movement. I discovered that this method is approximately ten times easier than simply pulling the statue on a sledge. This result encouraged me to continue. I decided to conduct an experiment and verify my theoretical results. This was in 1982. Because a trip to Easter Island wasn't possible, I thought of another solution. I gathered a group of enthusiasts

and they helped me build a clay mold and we cast a concrete replica. In this way I obtained a copy of a *moai* that was 4.5 meters high and of 12 tons weight. The shape was constructed from photographs.

The course of our experiment was as follows: we fastened several sets of ropes to the replica statue so we could pull it in different directions. One set of ropes was attached around the base of the statue. They were for twisting. Therefore their free ends could be used to pull the statue forward. The second set of ropes was fastened around the head of the statue; these were for tilting the statue to either side.

During the experiment, we tried to make the sculpture 'walk'. Nine men pulled the ropes fastened to the head of the statue. This group tilted the statue alternately. At the same time, the other group of eight men pulled the ropes fastened to the base. They turned it forward alternately to left and right.

We made a successful experiment in July of 1982. However, we tried moving the statue over a patch of bare earth. There had been rain for several days before our experiment, causing the bottom of the *moai* to sink in the mud. I wasn't satisfied with the experiment because, when the statue twisted, it moved the mud like a bulldozer.

Our next landmark experiment was in 1986. The Norwegian Kon-Tiki Museum prepared a second expedition to Easter Island. The leader of this was Mr. Thor Heyerdahl. I had written him a letter. Our test with the replica *moai* was of great interest to him and thus I became one of the members of the expedition.

There we made experiments with an authentic *moai*. First we conducted a test with one of the smaller statues. We needed to see how well we could cooperate with our collaborators from among the islanders. The statue we used was 2.80 meters high and weighed approximately 4-5 tons. Members of our expedition and the islanders needed a two day test to learn how to make the *moai* move. Three men tilted the *moai* and five others managed to twist the image forward. We repeated our trial with a bigger *moai* in Tongariki. This one was 4 meters high and weighed



Figure 1. Using a beam attached to the *moai* to twist and walk it over the ground. Drawing by Pavel.

about 9 tons. We needed seven people for tilting and nine for twisting the statue. In each case we moved them over dry soft soil containing some small stones. The experiments you can watch in SEBRA films/ Swedish movies: *Kon-Tiki Man*, and *Easter Island*.

Practical experiments gave us the actual numbers of men for pulling. These numbers could be reduced in various ways. For example, if a beam is fastened to the back of the *moai* in a horizontal position (Figure 1.), the beam will work as a lever. In this way, it is possible to reduce the force needed to twist the *moai* by one-half or even by two-thirds. I suppose that the aborigines learnt new skills and made some inventions during their three hundred years of moving *moai*. These skills encouraged them to cut and move a larger sculpture than the previous one, each time they tried it. Therefore it is a problem for us to solve the entire mystery. We need to sort our knowledge and archaeological evidence into a sequence according to when each actual *moai* was transported. We have to assume that there was progress in the transport technology on Easter Island too!

Two engineers from the Soviet Union suggested ways for the *moai* to walk. Alexandr Pestun and Pustem Valeev from Leningrad published their theory in a paper, "Konsomolskaja pravda" on 12 July 1986. They planned to produce a concrete replica weighing 40 or 80 tons. I kept in touch with them but they stopped their project soon after the article was published. They suggested that only one set of ropes be fastened to the head of the statue, expecting that the *moai* would twist itself if the direction of pulling was at an angle to the side and back of the statue. It is similar to a badly-hung door. When the hinges are not exactly one above the other, the door swings open or shut by itself.

I tested this idea myself in 1987. It was rather dangerous. We tilted our replica in the way Pestun and Valeev described, but the statue did not move on soft soil. I expected that there was a lot of friction under the statue. We put a flat stone under its base to act as a better pivot point for twisting. The result was similar but, because of the great pressure between the base of the statue and the flat stone, pieces of the base actually broke off from the corner.

In addition, I think that by this method the period of rocking/tilting the statue is too short for the center of gravity to effect a twisting motion.

Charles Love had another idea. He put a concrete replica of a *moai* on a sledge in an upright position. He fulfilled the islanders' claim that the statues were moved in an upright position. His test was successful in 1987.

I was once invited to demonstrate how to move a *moai* to

the general public in the Czech Republic. There were eleven thousand people at this performance. The organizers gave me a wet lawn as a place for the *moai* to walk. It was an interesting experience. The *moai* base sank 5-8 centimeters into the lawn! It started to tilt forward and backward during its walk. It was a surprise for me, and looked very dangerous. What had happened? As it twisted forward, one of the front corners of the base of the statue landed on an uncompressed patch of lawn which then acted as a spring and pushed the *moai* dangerously backward. The statue tilted back by 5-7 degrees. This could be an explanation of why the aborigines cut the bottoms of the *moai* at a slant. I believe they transported them as far as they could during wet seasons to reduce friction and wear on the bases.

The slanted base of the statues is probably the reason why aborigines placed a stone foundation underneath the base of the statues waiting to be moved along their route. One such foundation stone was found under statue #478, for example.



Figure 2. Showing the use of a lever arm to lift the pukao in steps onto the *moai*.

During the long time the *moai* was upright waiting to be moved on, it would have fallen forward because of the slanted base and the soft soil. The base of a *moai* is cut at a slant so its center of gravity is somewhere over the front half of the base, not over its center. This means there is more pressure on the soil at that point and a deeper sinking. But this is only my own explanation. It needs more direct research on the island.

I had one unsuccessful experiment, too. It was in my hometown of Strakonice. Canadian TV asked me to carry out a demonstration for Expo '86 in Vancouver several weeks after my return from Heyerdahl's expedition. We conducted this

experiment with my old 12 ton statue on flat hard soil (it was dry weather in that time). It was an important change against the experiment of 1982. The friction of the twisting was so great that 30 men were not able to do it. I received a new experience, thanks to that.

Walking a *moai* by levers is another possible method. This is a common method for moving a bank safe, for example. I tested it with advantage during our actions several times. For example, by this method we moved 30 tons of heavy stones with the help of only ten men. I tried this out on our 12 ton replica also. I expect this method was used in placing the *moai* on its *ahu* in every case.

We also tried to find out how the *moai* were transported down the slopes from the quarries to the foot of the volcano. I expected that aborigines used the method of wooden levers. We placed a replica on its back and 25 people operating with 14 beams of 4 meters length, were able to move the statue. This was during our first experiment in Strakonice in 1982. It

was very easy, but possibly very slow. I estimate the speed of transport is 10 centimeters per 5 minutes, which means 1 to 1.2 meters per hour.

The raising of the topknots, *pukao*, is another transport problem of Easter Island. What method did the aborigines use? We have several theories. William Mulloy supposed the *pukao* was fastened to the *moai* and erected with it. But there is one question.

Our experiment and research supposed that some of the

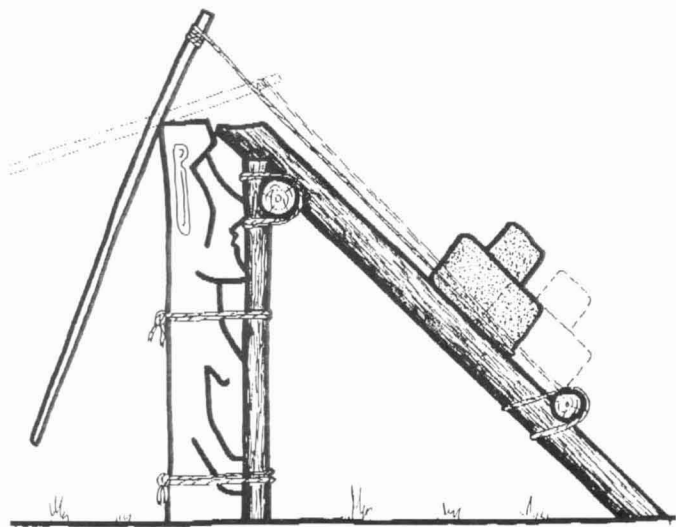


Figure 3. Moving the *pukao* up the two beams with a lever.

moai were transported in an upright position. This means that they were erected below Rano Raraku quarry and 'walked' across the island. Does this mean that the statues carried their *pukao* the entire route from Rano Raraku to their *ahu*? It is not

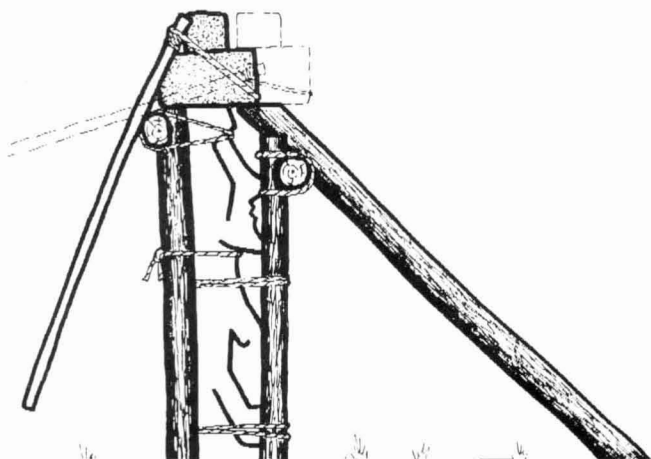


Figure 4. Moving the *pukao* into position on top of the *moai*.

probable, I think. There is another idea. The natives built a zig-zag of stones next to the upright statue. The hat was rolled from side to side, each time to a higher position. The *pukao* was pushed over onto its side when it was level with the top of

the statue. Another theory suggested that the islanders built a sloping ramp of stone from ground level to the top of the *moai*. It takes a lot of time to build such a pile and needs several tens of cubic meters of stones. But perhaps it was possible to get the hat on top of the *moai* even without the beams. I started to study this problem.

We made a second concrete replica of a *moai* in 1986. It was 3 meters high and weighed 4 tons. We made a concrete replica of a *pukao* also. It's diameter was 1 meter and weight was 900 kilograms.

Our experiments took three months. A small model of a *moai* and *pukao* on a scale of 1:10 gave us the solution. We fastened the *pukao* with ropes to the end of a beam. It was the shorter end of a lever that laid on top of the *moai*. The longer end pointed in front of the *moai*. When we pulled the long end



Figure 5. Photo of the arrangement of beams and levers used to lift a *pukao* onto a *moai*.

of the lever down, the short end went up and lifted the hat. This arrangement is shown in Figure 2. Then we supported the hat so it could not fall and shortened the ropes on the lever. We repeated this process until the *pukao* was level with the top of the *moai*. Then we used the beams as a lever pivoted in the eyes of the *moai* to tilt the hat until it was horizontal. I assume this is one of the reasons why the eye sockets were cut on the *moai* after they were erected on the *ahu* platform.

This method looks very complicated and dangerous, but we collected evidence that it is definitely possible. There are no problems from a technical point of view.

The using of the two beams looks to be an easier method. We successfully tested this method with a 6 ton lintel in 1990. During 6 months we demonstrated how the lintels of Stonehenge could have been raised onto the uprights. This method is easier and safer than the previous one and I believe it was probably used for lifting the *pukao* hats, in the end.

Granite Productions of London joined me in 1994. They asked me to conduct an experiment with lifting a *pukao* for a TV documentary on Easter Island for a series entitled *Arthur C. Clarke's Mysterious Universe*. I decided to test the method of the two beams, using our concrete statue from the previous experiment. My method consisted of pulling the *pukao* up two

sloping spruce beams that were leaning against the statue. They were 7.5 meters in length with an average diameter of 30 cm. The *pukao* lay on the ground near the lower ends of the sloping beams. We put one spruce beam horizontally across the top of the statue. It was our lever, 4 meters long and with an average diameter of 20 cm. The shorter part of the lever was above the *pukao* and fastened by ropes to it, the longer one behind the statue.

A group of laborers pulled these longer parts down, and the opposite end rose up in a step of about 30 cm. A beam was fastened across the sloping beams by ropes to stop the *pukao* from sliding down between pulls. The hat was fastened to the lever by one 20 meter long rope of 30 mm in diameter. We de-barked the beams and lubricated the surfaces with mashed potatoes before attempting the experiment.

It was a surprise for us that only 4 men were needed to raise the hat. One person was stationed on top of the statue and stopped the *pukao* from moving back. The others acted as a living load on the longer part of the lever. Raising the *pukao* took us only 6 hours. This arrangement is shown in Figures 3 and 4 and in the photo Figure 5.

Granite Productions wished more tests. First we pulled a statue on a sledge on grass. Thirty men were unable to move it. I fulfilled a special wish of the producer who had bought 800 kilograms of potatoes. We covered the road beneath and in front of the sledge with a layer of potatoes. The pulling was easier; the same group was able to move the sledge with the statues. We went only six meters. The sledge took 30% of the mashed potatoes. It was the second test; I used that opportunity and situated the sledge on beams 2 meters long and 20 cm in diameter. The result was evident; only ten men were needed to pull the statue.

My study about transport of the *moai* took 12 years. All those attempting to solve the problem made the same mistake as I did. We took the question of the *moai* transport as one problem. There was simply the question, "How were the statues transported?" and nothing more. There are many sorts of statues on Easter Island. Their shape is very similar but their proportions are different. The weight depends on the proportions, and weight is the most important problem for transport.

For example, a statue 4 meters high is two times higher than a statue that is 2 meters, but 8 times heavier. I comprehended the problem as one according the statue proportions. A method needed for transport of a 200 kilogram statue was certainly different from the method for moving a 20 ton statue, wasn't it?

The similar problem is with the analysis of transport routes. The transportation trail from the quarry of Rano Raraku was probably different from the route crossing the island or from the finished transport road direct to an *ahu* platform. When we determine the statue and part of its trail we can start with the discussion of "How was this *moai* transported to that place."

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